

An aerial photograph of a coastal town and estuary. The town, with its residential and commercial buildings, is situated in the lower center. A winding river or estuary flows from the town towards the ocean, creating a large, irregularly shaped body of water. The surrounding landscape is a mix of green fields, forests, and distant hills under a sky filled with large, white clouds.

# A VOC Offset from CO

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Smog Reyes

# The VOC Offset from CO

- Four Key Issues:
  - Permeation
  - Total CO emissions and ratio to VOC
  - Reactivity of CO relative to VOC
  - Reduction of CO from oxygen (today's focus)

# Ethanol Induced Permeation

- Permeation a decreasing problem.
- Range of uncertainty.
  - <11.5 to 30 tons per day in SCAB due to temperature.
- ARB analysis of CRC study currently focused on 1.1 grams per day per vehicle.
  - 23.9 million gas vehicles implies 24 tons per day statewide.

# Total CO emissions and ratio to VOC

- Total increased (in EMFAC) since 1999 construction of PM (Appendix G)
- Ratio currently about 13 to exhaust VOC
- Tunnel data and 1998 vehicle study show about 20 to 1 ratio.
- New standards and data up to 100 to 1 (e.g. SULEV).

# Reactivity of CO relative to VOC

- European reactivity ratio about 10 to 1.
- EPA has reported 15 to 1.
- MIR predicts 59 to 1 (48 to 1 in PM).
- New ARB study 39 to 1 based on SIP grid model instead of high-NO<sub>x</sub> box-model used for MIR's.

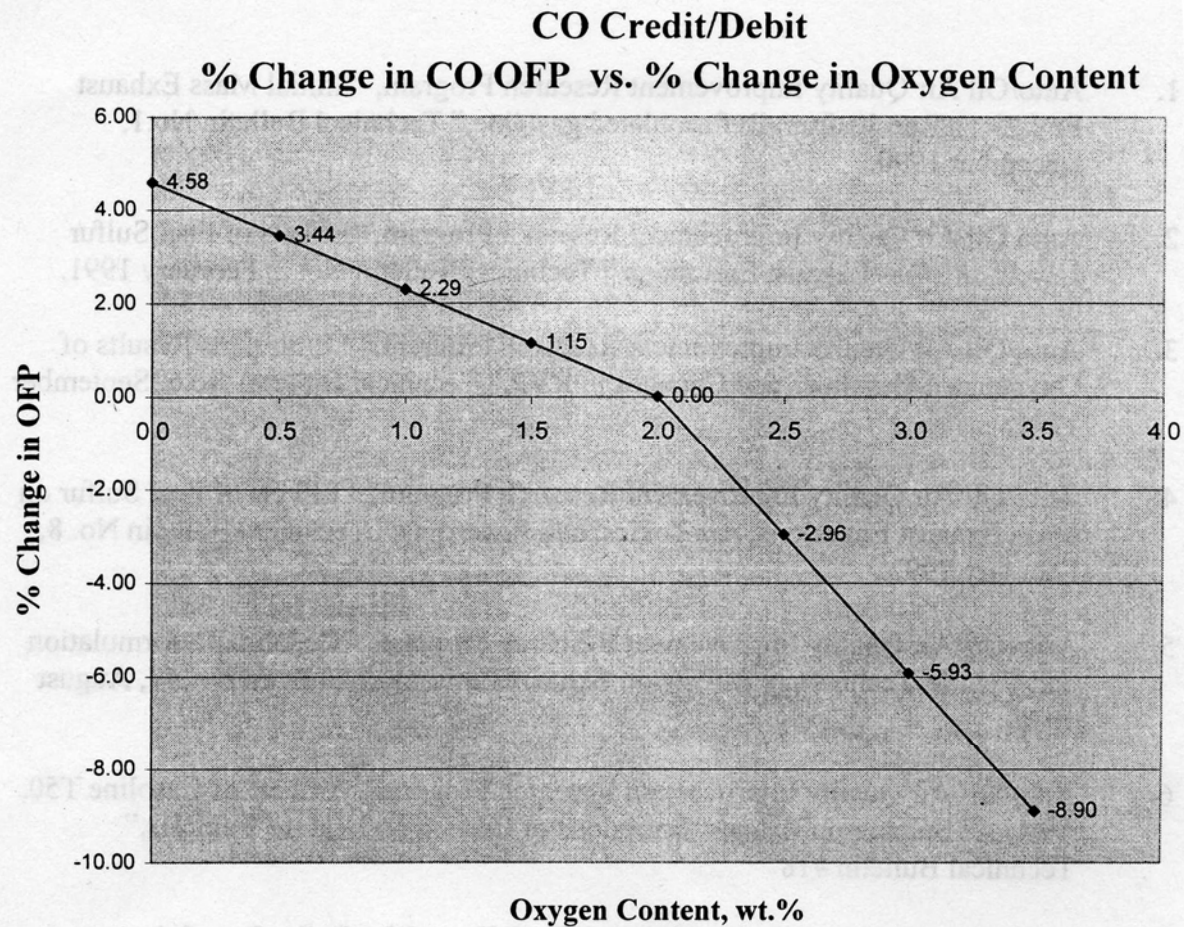
# Reduction of CO from oxygen

- Current regulations use Predictive Model for oxygen when over 2 weight percent (5.7 volume percent ethanol).
  - CO reductions used to give additional VOC credits.
- Below 2% oxygen no VOC debits are charged for CO increases (due to ethanol permeation).
- CO reactivity factor used in PM is 48 to 1.
- ARB (based on EMFAC) claims E5.7 lowers CO 7.8 grams per day per vehicle.
  - Thus, 1.1 g. permeation can not be compensated by 7.8 grams CO at 48 to 1 reactivity.

# Reduction of CO from oxygen

- Statewide EMFAC shows 23.9 million gasoline vehicles.
  - 7.8 grams per vehicle then 169 tons per day.
- Statewide ARB gasoline on-road CO inventory is 7243 tons per day (2005 summer).
- This implies less than 1.2% CO reduction per percent oxygen in fuel or 2.4% total.

# Reduction of CO from oxygen



# Reduction of CO from oxygen

- Figure (from Appendix G of '99 Staff Report on CaRFG3) shows over 2% CO reduction per oxygen percent below 2 weight percent oxygen or 4.58% total.
- Appendix G and '99 FSOR states that extra low CO reduction (increase) due to sulfur and T50 adjustments to meet VOC requirements in non-oxy.
- However, enforcement data show non-oxy mainly meet VOC via RVP reductions that do not impact CO. This trend likely to continue.

# Reduction of CO from oxygen

- In 1992 ARB claimed 2% oxygen would reduce wintertime CO by 10% and reduction was linear at least to 2.7% fuel oxygen.
- Caldecott data showed 21% CO reduction from 2% fuel oxygen in spite of higher S in the oxygenated fuel.

# Reduction of CO from oxygen

- Next, the Figure shows major “break” from slope above 2 weight percent oxygen.
- Figure shows 2.19% below 2% Ox and 5.93% percent reduction rate above 2 oxygen percent.
- Yet '97 “blue ribbon” OSTP report implies that CO reductions be treated linearly with fuel oxygen and that the rate of reduction is between 3 and 10 percent reduction per oxygen percent.

# Reduction of CO from oxygen

- 5.93% reduction rate in PM for  $Ox > 2\%$ .
- But Appendix G shows that derivation of 5.93% rate assumes zero impact from all vehicles mfg.'d after 1995 (Tech 5).
- Alliance 2001 data and recent CRC-67 consistent with 7.3% rate for Tech 5.
- Using 7.3% in Appendix G derivation leads to 8.96% rate in place of 5.93% rate.

# Reduction of CO from oxygen

- Note: App. G base is 4995 tons per day.  
296.44 tons CO reduced is 5.933%.

**Table5. Calculations of CO Reductions Base on FTP and REPO5 Emissions**

	81-85 MY	86 to 90 MY	91 to 95 MY	95 to 05 MY	Total
% CO Reduction per wt. % Oxygen	-5.07%	-4.76%	-1.35%	0.00%	
WT. % Oxygen Increased (1.0)	1.00	1.00	1.00	1.00	
Weighted / FTP COMP	2.8	2.8	2.8	2.8	
Adjusted CO Reductions	-101.08	-156.01	-39.35	0.00	-296.44
Ozone Reduction from CO Reductions	-7.08	-10.92	-2.75	0.00	-20.75

# Reduction of CO from oxygen

- 8.96% rate implies a 21.8% increase in CO from flatline 2 weight percent oxygen to non-oxygen.
- A 21.8% increase of 7243 tons per day is 1579 tons of CO increased from the use of non-oxygenated gasoline over flatline.
- For 23.9 million vehicles 1597 tons implies a non-oxygen CO increase of 60 grams per day per vehicle over E5.7
  - For E10 the overall CO difference would be 105 grams.
  - In tons for E10 the CO difference would be 2770 tons per day.

# Reduction of CO from oxygen

- 60 grams is nearly a factor of 8 higher than ARB staff's estimate of 7.8 grams per day CO difference between flatline (E5.7) and non-oxy fuel.
- Even with a MIR reactivity ratio of 59 to 1, a 60 grams CO reduction comes very close to full compensation for the 1.1 grams per day permeation estimate.
  - For the reactivity ratio of 39 to 1, the 60 grams of CO would imply a VOC compensation of 1.5 grams permeation per vehicle per day.
    - For E10 the VOC would be 2.6 grams (70 tons statewide).